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Music in learning and re-learning – The lifespan approach

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Abstract

During past decades, our knowledge about the brain functions and structures underlying music perception, performance, and emotions has accumulated relatively fast. However, much less is known about the brain determinants underlying music learning and music rehabilitation. In my contribution, I will briefly illuminate the results of music learning on brain functions in newborn infants, toddlers and school-aged children. Furthermore, I will discuss results about music rehabilitation obtained from neurological patients. Taken together, these data indicate that music can be learnt across the whole life span, and, further, that it can be used in neurorehabilitation in a highly versatile manner.

Key words: Music cognition, Music education, Music rehabilitation, Auditory learning, Transfer effects

Thanks to advances in neuroscience and music psychology, we are now in a better position to understand the secrets and possibilities of music in improving the quality of human life. In my SysMus 2016 keynote, I used lifespan framework to illustrate the outcome of these studies in the newly established field of neurosciences of music. Of particular importance in this context were the findings on learning and rehabilitation (re-learning).

In this framework, we can start observations about the auditory learning already preceding the birth: music learning was recently empirically shown to start already at the fetal stage. This was evidenced when pregnant mothers-to-be were committed to listen researcher-selected auditory material during their late pregnancy. The sounds were presented with loudspeakers so that the sounds were audible also in the womb. After the babies were born, their sound-related brain responses were compared with the babies whose mothers had not listened to this material. Right after their birth and even at the age of four months, the brain responses of the babies reflected the existence or lack of music exposure (Partanen, Kujala, Tervaniemi, & Huotilainen, 2013): the brain responses of music-exposed babies were stronger than the responses of naïve babies. Here, “Twinkle twinkle” was used both during the exposure and also during the brain recordings. In a similar vein, linguistic material was used during the exposure and during the recording. It was found that pseudoword “tatata” and its modifications with a pitch change resembling a prosodic change evoked larger brain responses in the babies whose mothers had been listening to the sounds while the brain responses two different kinds of pseudowords were indiscriminable in the babies who had not been exposed to those prior to their birth (Partanen et al., 2013).

In toddlers and school-aged children, music listening gives joyful moments and can also help them soothe and relax. Learning to play an instrument or joining a choir gives a special possibility to shared music moments and feelings of cohesion. Since pioneering findings of Hyde et al. (2009) and Shahin, Roberts, Chau, Trainor, and Miller (2008), there are tens of findings indicating various effects which music has on developing brain. In a similar vein, there is now empirical evidence about the possibilities of music to enhance children's neurocognitive development as well. Most robust these effects are with regard phonological skills which carry importance for learning to read (Dege & Schwarzer 2011; Kraus et al. 2014; Slater et al. 2014): children involved in musical training have more sensitive encoding of the phonemic information when compared with their nontrained peers. With regard general cognitive processes (attention, working memory, and executive functions), there are plenty of positive findings of music training to enhance these higher-order functions as well (Benz et al. 2016). However, these effects are quite sensitive to the testing paradigms and thus more research on this domain is needed (see critical review by Jaschke, Eggermont, Honing, & Scherder, 2013).

Importantly, even casual family-oriented music activities taking place at home are found to be beneficial for the child's cognitive development. Voluntary and self-initiated dancing, singing, and listening to music at home were associated with advanced attentional neural functions (Putkinen et al. 2013; Putkinen et al. 2015). While this original finding was obtained with toddlers with intact hearing abilities, these casual music activities were also highly beneficial in deaf-born children who learnt to hear after receiving a cochlear implant (an electric hearing aid) (Torppa et al. 2014). In them, the frequency of music activities was positively associated with improved linguistic skills.

In adult musicians, we evidence multitude of perceptual, cognitive, and motor benefits of music expertise also at the brain functions and structure when compared with musically non-trained individuals. Of interest in this context is to note that musicians are not the same (Tervaniemi 2009), instead, their training background is mirrored in their brain indices. It has been shown that professional jazz musicians have enhanced neural encoding of all sound features included in the paradigm, namely, pitch, pitch slide, location, rhythm, intensity, and timbre [Vuust Brattico, Seppänen, Näätänen, and Tervaniemi, 2012]. Using a different melody-based paradigm (Figure 1), classical and rock musicians were shown to have more specific profiles with enhanced responses to mistuning and timing (classical musicians) and to melody contour (rock musicians) (Tervaniemi, Janhunen, Kruck, Putkinen, and Huotilainen, 2016).

Naturally by investigating adult musicians in a cross-sectional setting, it is not possible to draw firm conclusions about the causality of these auditory sensitivities: it is possible that predispositions to given sound features existed already before the commitment of music training, guiding them towards genre(s) in which these features are important. However, based on a semi-longitudinal study on children from 9 to 13 years of age, this is not necessarily the case (Putkinen, Tervaniemi, Saarikivi, de Vent, and Huotilainen 2014). As seen in Figure 2, in the first recordings at the age of 9 which used the paradigm of Figure 1, the brain reactions to several changed embedded in a melody did not differ between musically trained and non-trained children. For mistuning, rhythmic modulation, and timbre change, the groups differed at the age of 11 years and for melody modulation and timing delay at the age of 13 years. Thus, enhanced discriminatory reactions seem to gradually emerge during the music training, at least in these children who are involved in a classically oriented training.

Last but not least, in the current lifespan framework for music benefits, we welcome also the positive impact music can have on the elderly. Taken into account the increase of the number of the elderly citizen, leading to higher needs of geriatric, psychiatric, and neurological health care, it is worthwhile to consider all possible easy-to-implement means to alleviate their physical and mental conditions and subsequent societal needs.

Already now we know that neuronal decline is slower in healthy individuals with prior music practice and hobbies in terms of auditory and cognitive functions (White-Schwoch, Carr, Anderson, Strait, and Kraus*,* 2013 and Hanna-Pladdy & MacKay, 2011; for reviews see Strait & Kraus 2014; Alain, Zendel Hutka, and Bidelman, 2014). At the same time we know that, based on every-day evidence, there is no upper limit for musical learning to be started, just the opposite: also the elderly can well learn (or re-learn) to play an instrument (Bugos, Perlstein, McCrae, Brophy, and Bedenbaugh, 2007) and to perform in public as a member of a band or to sing in a choir [e.g., see examples at a www site of music school for students with special needs, including the elderly: www.resonaari.fi].

On the other hand, we also have evidence indicating that patients who have a diagnosed memory disorder can be treated with music sessions, based on singing and listening to familiar songs. After 10 such group-based sessions jointly with the care-givers, their cognitive decline was reduced, importantly irrespective the musical background of the participants (Särkämö et al. 2014; Särkämö et al. 2015). We also know that listening to one’s favorite music after a stroke can facilitate both cognitive and emotional recovery as well as increase the quality of life of the patients (Forsblom, Särkämö, Laitinen, & Tervaniemi, 2010; Särkämö et al., 2008). In parallel, both functional and structural changes in the brain can be observed (Särkämö et al., 2010, 2014). These inexpensive and easy-to-implement ways of using music in neurorehabilitation can append therapist-driven forms of music therapy in a very fruitful manner (Sihvonen et al., in press).

To sum up, music can be learnt across the whole lifespan. Also, it can enrich learning and rehabilitation in a highly motivating manner. It remains to be seen how much this knowledge will be utilized in learning sciences and rehabilitation in future. In this context, we should also be open to new endeavors, such as novel digital music environments and applications as well as systematic group-based interventions, for instance, choir singing or dancing. All these activities could be utilized by a great variety of individuals of different age with and without special needs. Yet, once again, we first need evidence-based studies to validate these novel practices before giving recommendations for their larger-scale use.

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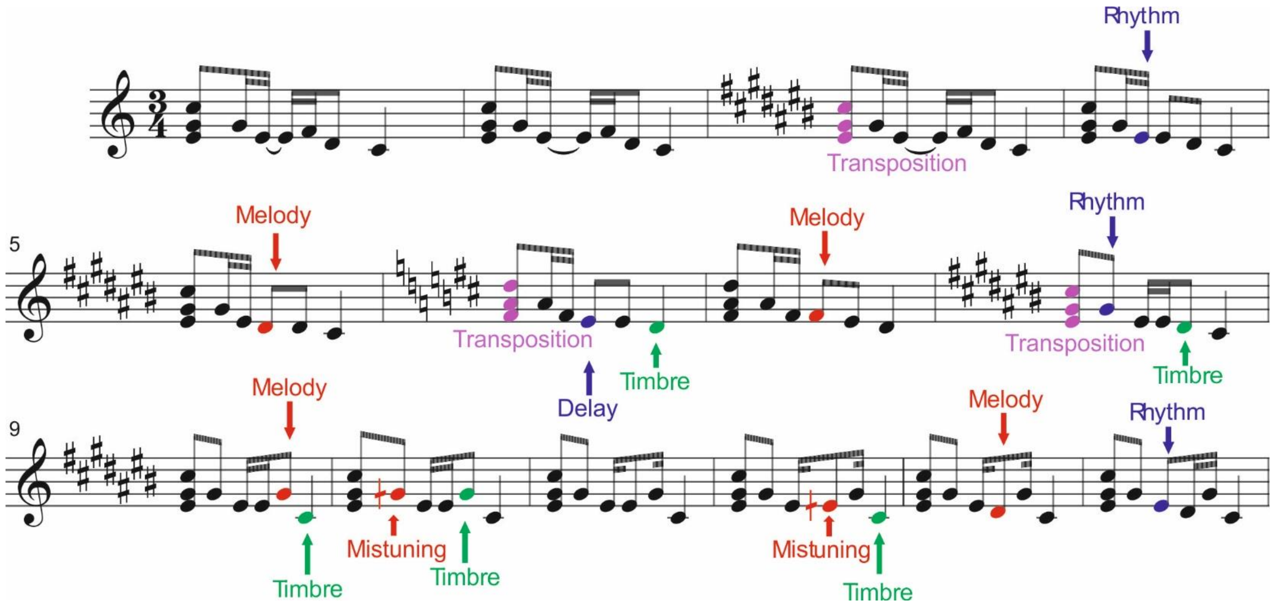
Figure legends

Figure 1. Melodic MMN paradigm. The melodies with total of 6 different deviants were presented via headphones while the participants were watching a silenced movie for < 15 minutes. From Tervaniemi, Brattico, and Huotilainen, 2014, with permission.

Figure 2. Difference signals (ERPs to standard tones subtracted from deviant tones) from children with musical training (continuous line) and without musical training (dashed line). Children participated in the ERP recordings several times while they were 9, 11, and 13 years old. Reprinted from Neurobiology of Learning and Memory, 2014, 110, by Putkinen, Tervaniemi, Saarikivi, de Vent, & Huotilainen, Investigating the effects of musical training on functional brain development with a novel Melodic MMN paradigm, with permission from Elsevier.



Rhythm
Transposition
5
Melody
Melody
Rhythm
Transposition
Transposition
Delay
Timbre
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9
Melody
Melody
Rhythm
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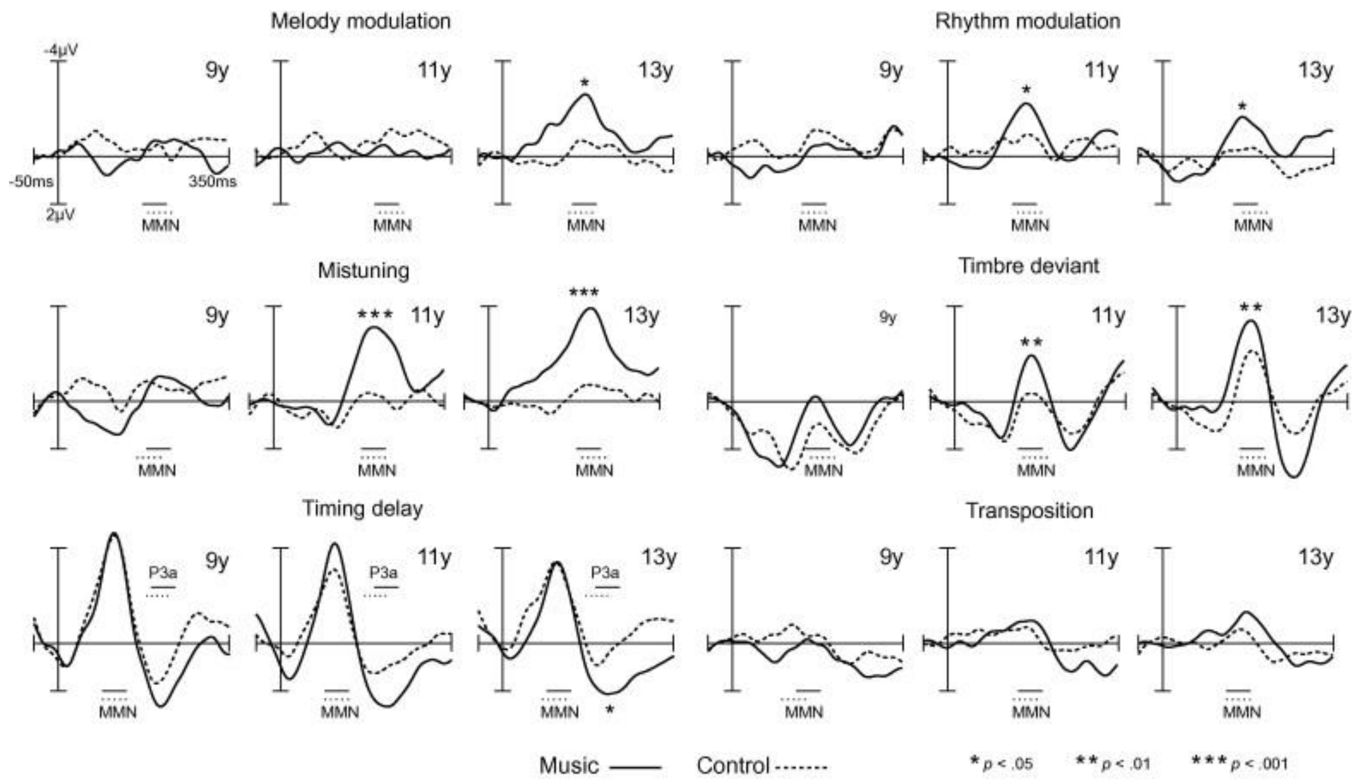
Melody modulation
Rhythm modulation
Mistuning
Timbre deviant
Timing delay
Transposition
-4μV
2μV
-50ms
350ms
9y
11y
13y
MMN
P3a
Music
Control
* p < .05
** p < .01
*** p < .001